Carbon Sequestration R&D Overview

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2nd U.S/China CO_2 Emission Control Science & Technology Symposium
May 28-29, 2008
Hangzhou, China

Office of Fossil Energy

Technological Carbon Management Options

Reduce Carbon Intensity

- Renewables
- Nuclear
- Fuel Switching

Improve Efficiency

- Demand Side
- Supply Side

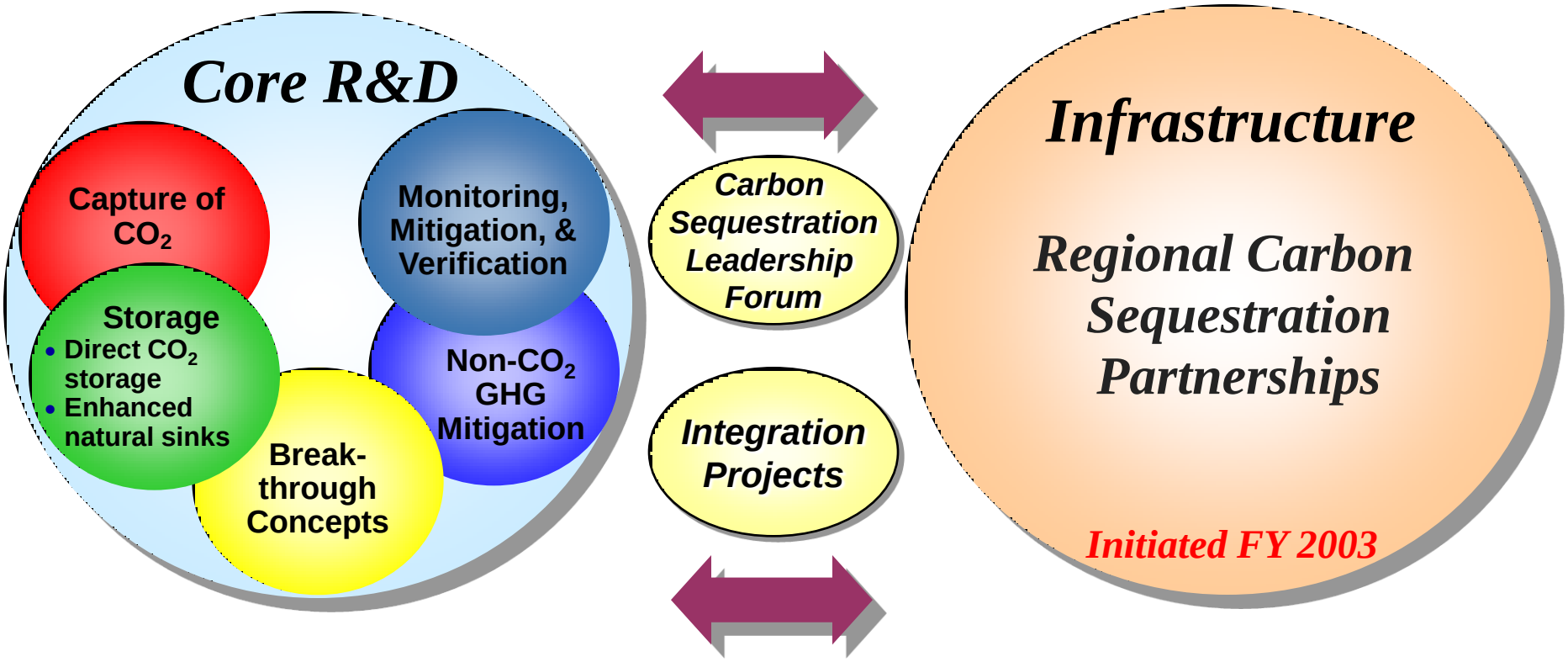
Sequester Carbon

- Capture & Store
- Enhance Natural Sinks

All options needed to:

- Affordably meet energy demand
- Address environmental objectives

DOE's Sequestration Program Structure

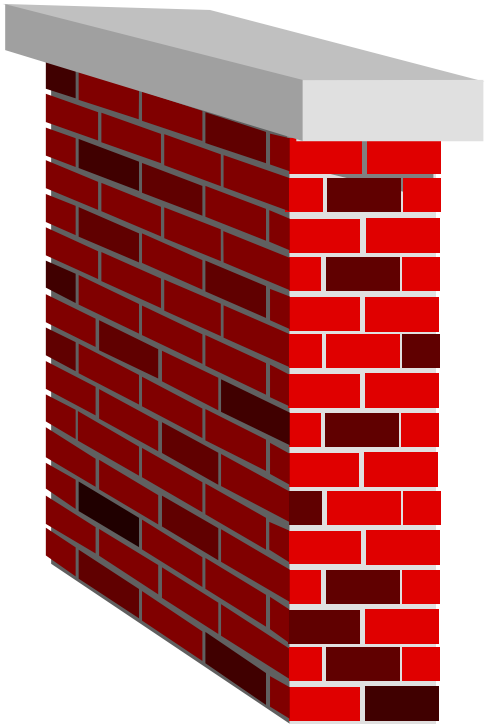


Carbon Sequestration Program Goals

- **Deliver technologies & best practices that validate:**
  - 90% CO_2 capture
  - 99% storage permanence
  - <10% increase in COE (pre-combustion capture)
  - <20% increase in COE (post- and oxy-combustion)
  - +/- 30% storage capacity

Key Challenges to CCS

- **Sufficient Storage Capacity ?**
- **Cost of CCS ?**
- **Permanence ?**
- **Infrastructure ?**
  - Transport Lines
  - Permitting
  - Regulatory framework
  - Public Acceptance (NIMBY → NUMBY)
  - Liability
  - Best Practices
  - Human Capital Resources



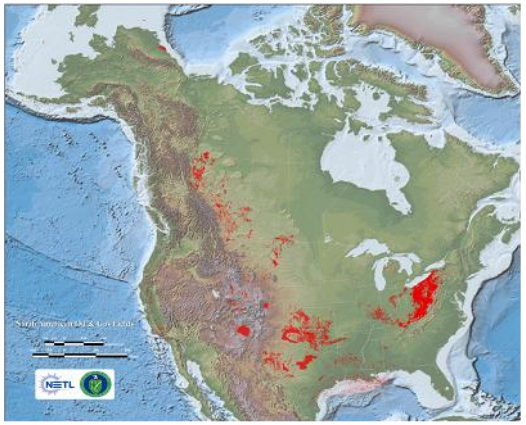
Sufficient Storage Capacity ?

- **Validate Storage Capacity to +/- 30% Accuracy**

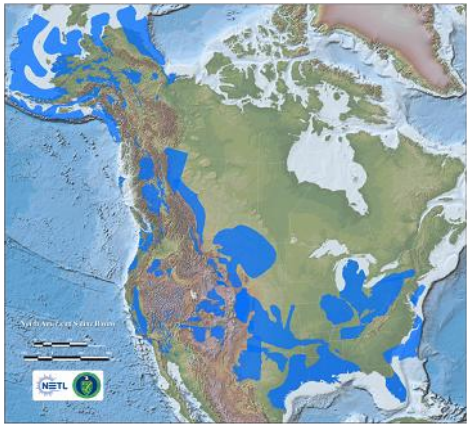
National Atlas Highlights

Adequate Storage Projected

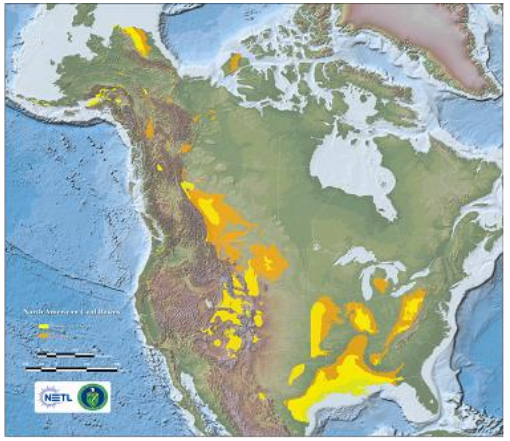
U.S. Emissions ~ 6 GT CO_2/yr all sources



Oil and Gas Fields



Saline Formations



Unmineable Coal Seams

Conservative Resource Assessment

North American CO_2 Storage Potential (Giga Tons)

Sink Type	Low	High
Saline Formations	969	3,223
Unmineable Coal Seams	70	97
Oil and Gas Fields	82	83

Hundreds of Years of Storage Potential

Available for download at http://www.netl.doe.gov/publications/carbon_seq/refshelf.html

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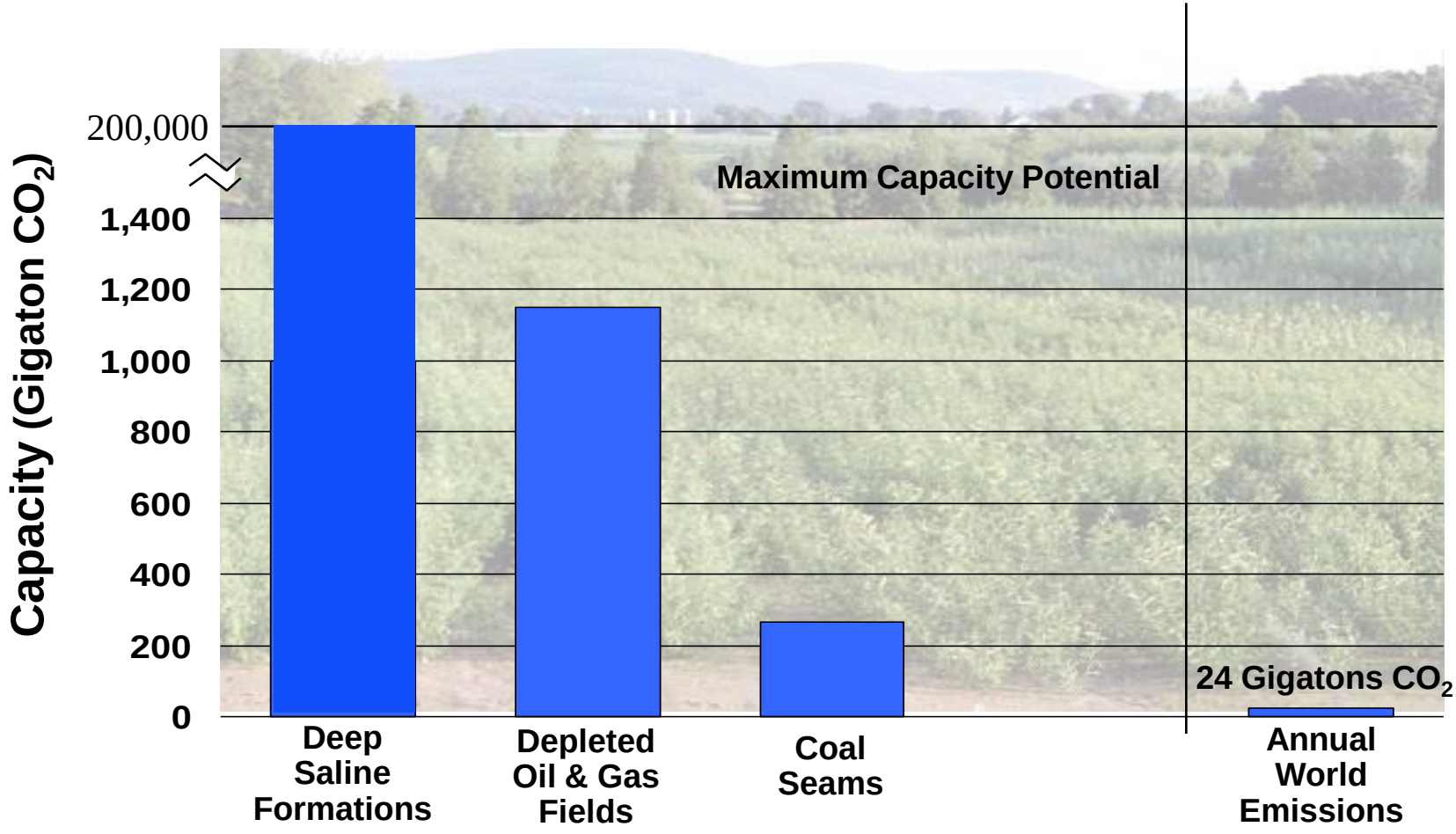
Worldwide Geologic Storage Capacity

Thousands of Years of Potential Storage Capacity



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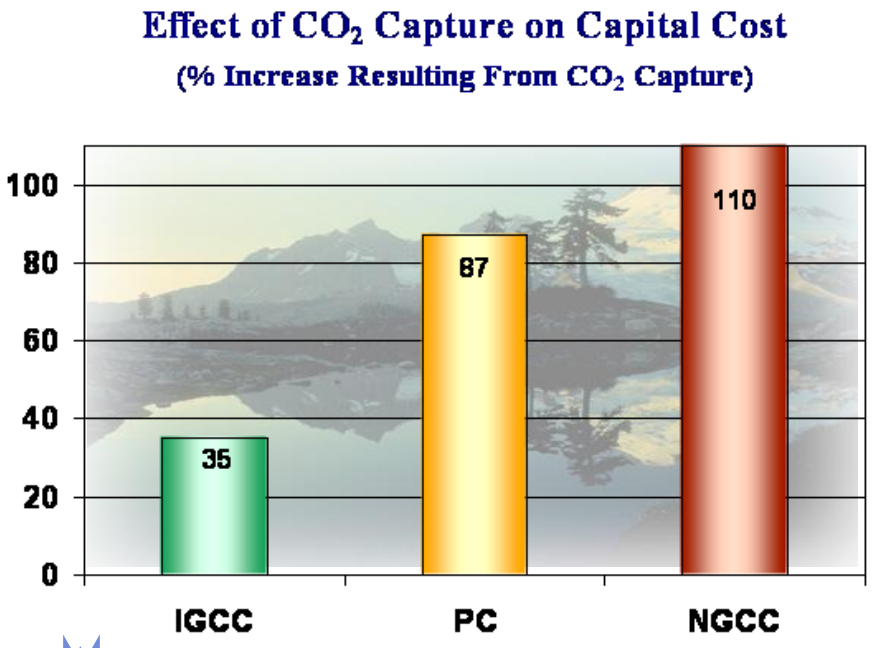
Storage Options: *IEA Technical Review (TR4), March 23, 2004*
World Emissions: *DOE/EIA, International Energy Outlook 2003, Table A10*

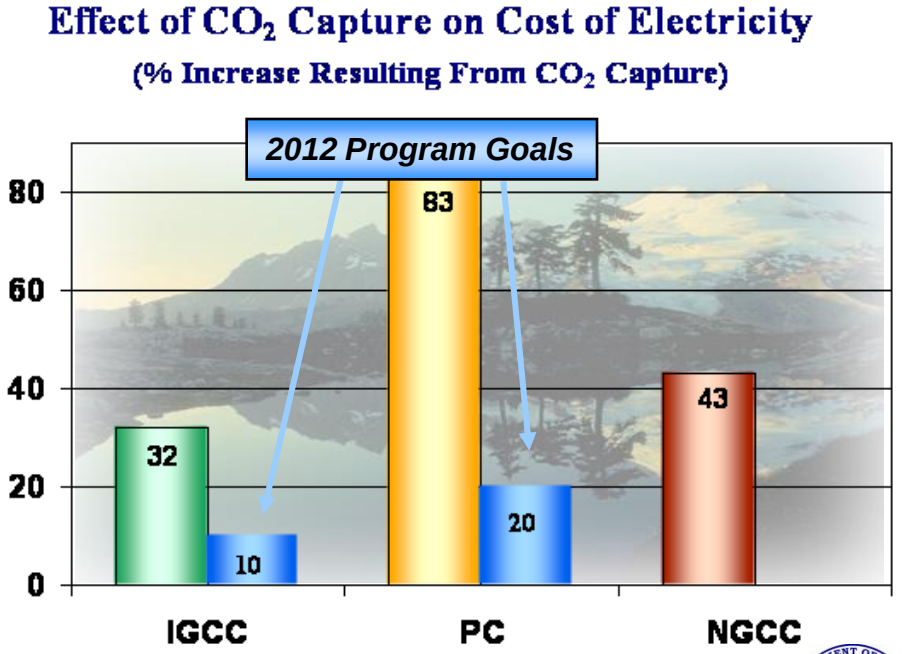
Cost of CCS ?

- < 10% increase in COE (pre-combustion capture)
- < 20% increase in COE (post- and oxy-combustion)

CCS Is Expensive!

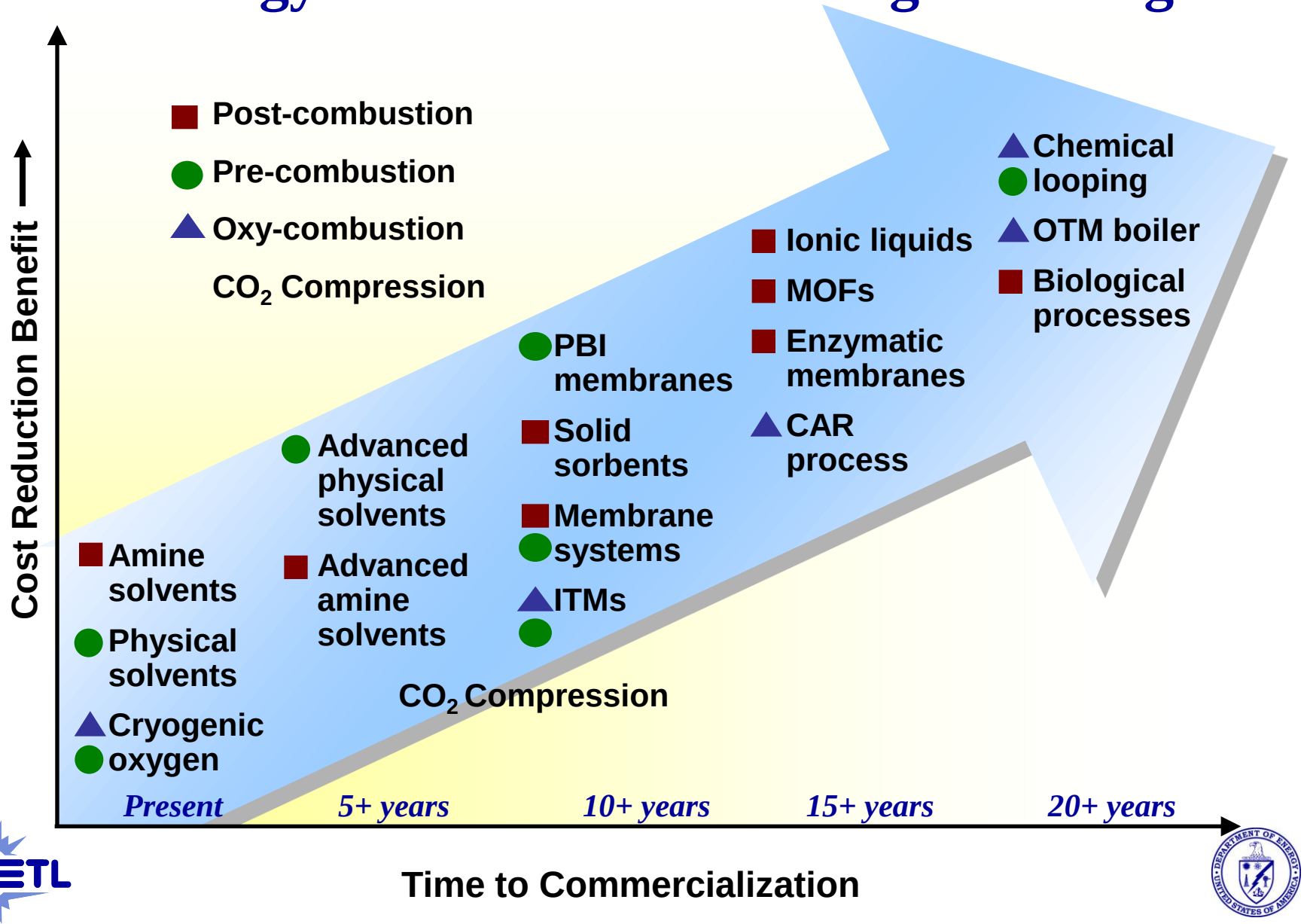
- 5–30% parasitic energy loss
- 35–110% increase in capital cost
- 30–80% increase in cost of electricity





Source: Cost and Performance Baseline for Fossil Energy Power Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity

Technology Advances Are Starting to Emerge



Permanence ?

- Develop tools, protocols & best practices
- Verify 99% storage retention

Tools, Protocols, and Best Practices

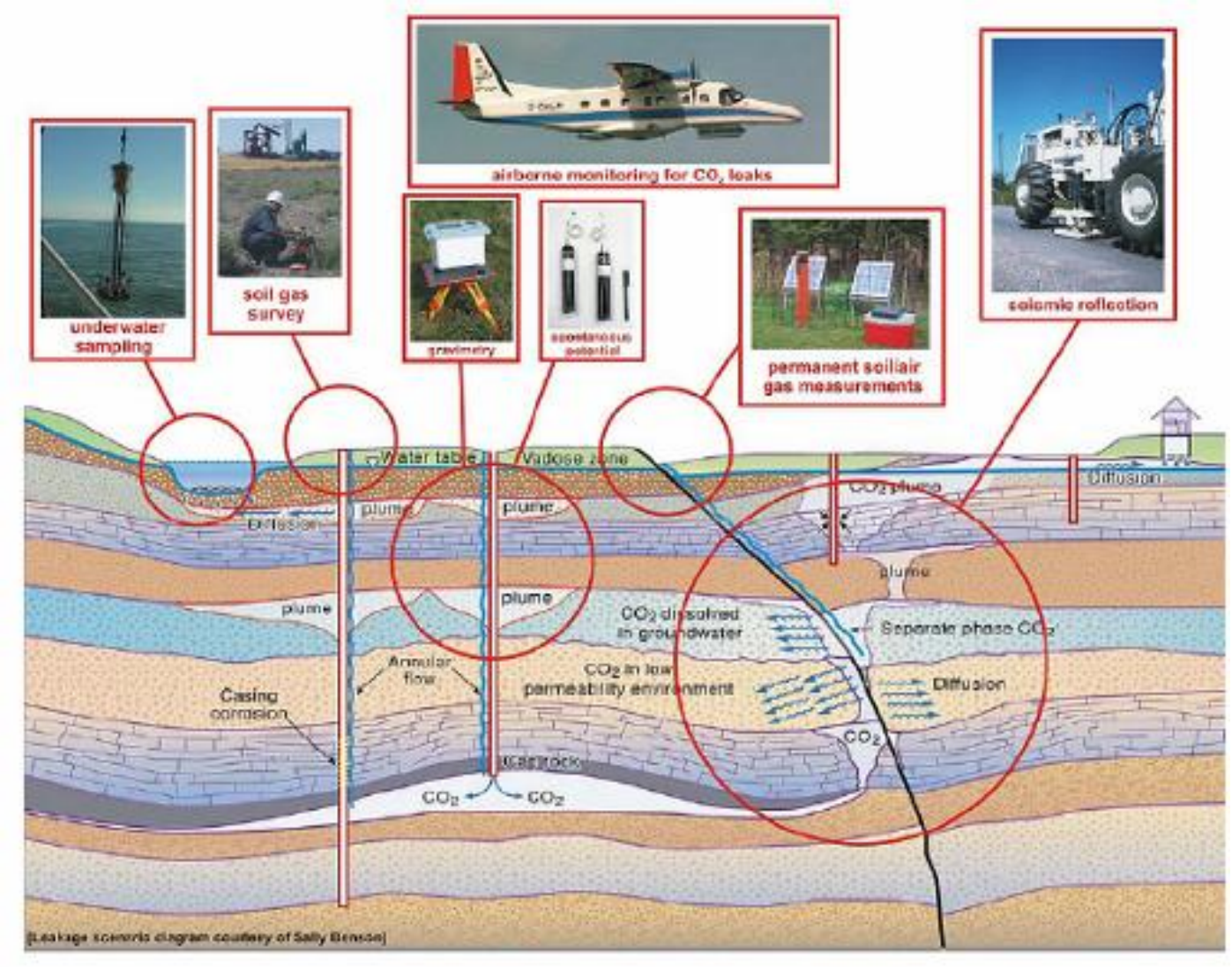
All Risks & Leakage Pathways Are Being Studied

- **Environmental Risks**
  - Migration into other strata, displacement of underground fluids, …
- **Health and Safety Risks**
  - CO_2 is a nontoxic, inert gas that displaces oxygen - asphyxiation
- **Economic Risks**
  - Liability and operational considerations, EOR commercially proven

Best Practices Manual (BMP)

- **Developing Science Protocol FY08 w/Office of Science**
  - Geologic characterization, site development and operations, risk assessment and mitigation strategies, implementation, outreach,…
- **Evolve into BMP as research continues**

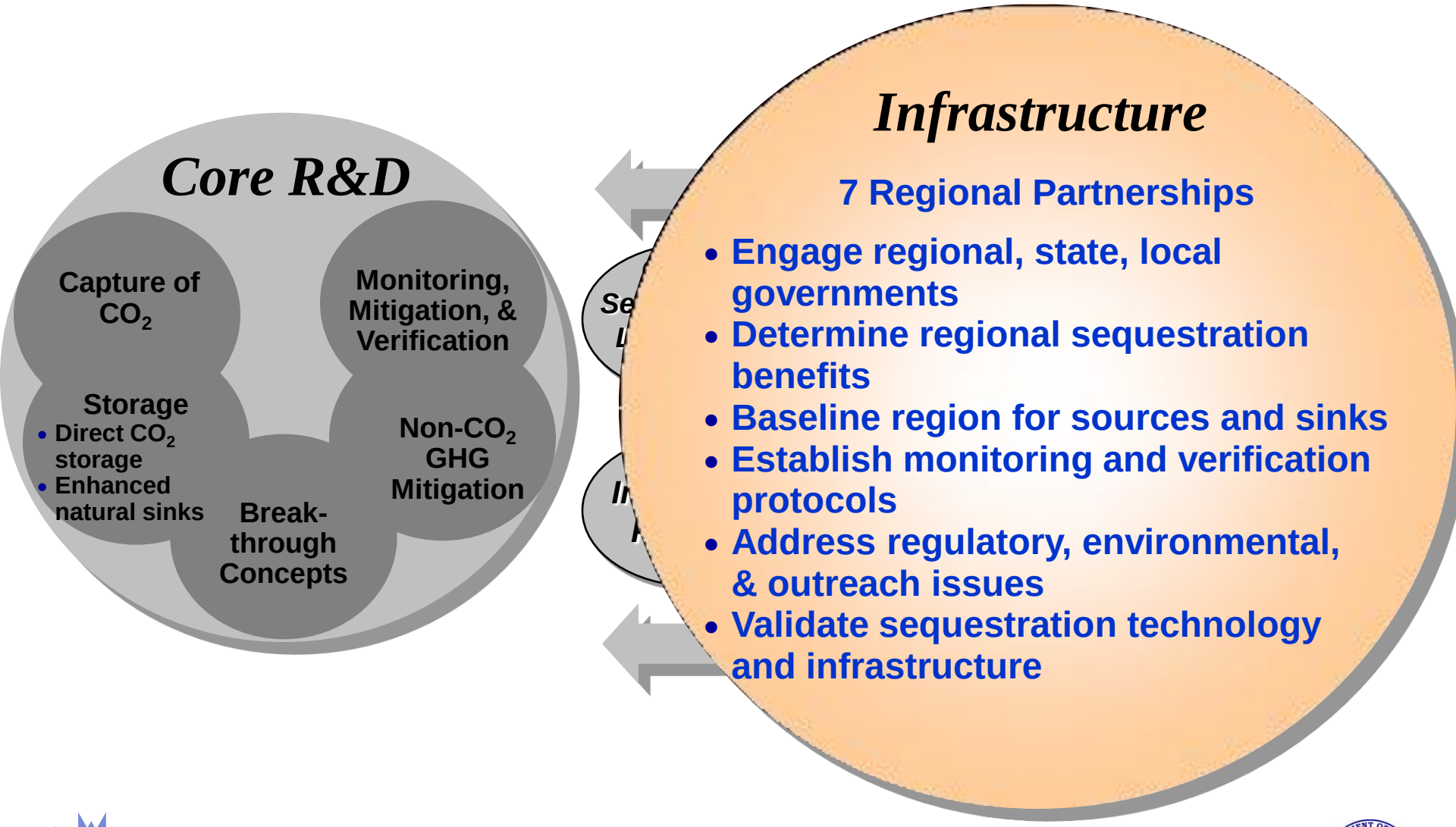
Monitoring, Mitigation, and Verification Technologies & Protocols Are Emerging



Infrastructure ?

- Put “first-of-kind” projects in place
- Develop protocols & best practices
- Regional Carbon Sequestration Partnerships

DOE's Sequestration Program Structure



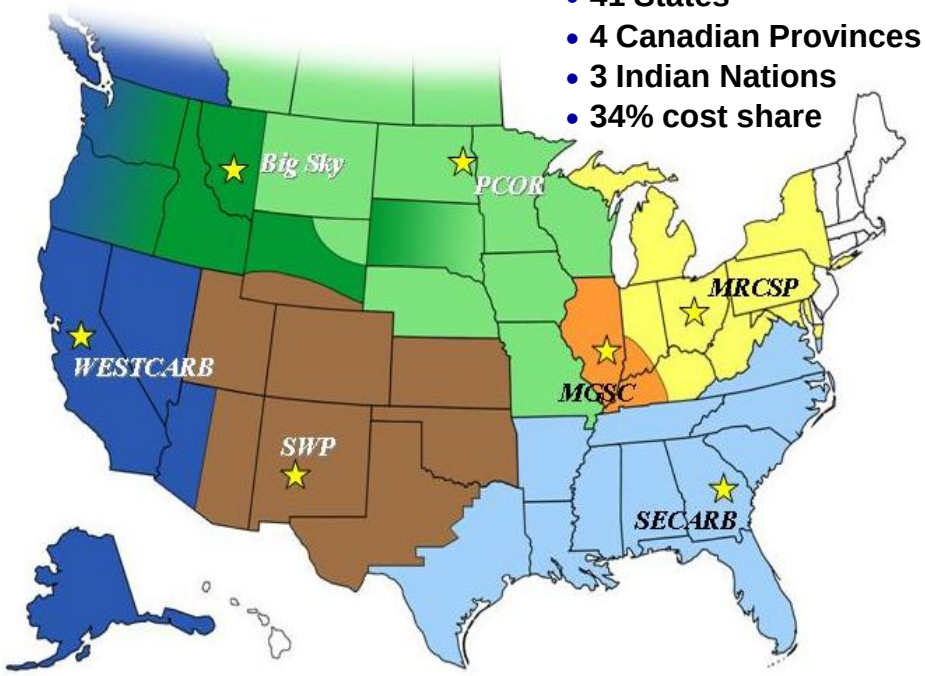
Regional Carbon Sequestration Partnerships
Creating Infrastructure for Wide Scale Deployment

Representing:
- **>350 Organizations**
- **41 States**
- **4 Canadian Provinces**
- **3 Indian Nations**
- **34% cost share**

Characterization Phase
- 24 months (2003-2005)

Validation Phase
- 4 years (2005 - 2009)
- 7 Partnerships (41 states)
- 25 Geologic field validation tests

Deployment Phase
- 10 years (2008-2017)
- Several large injection tests in different geology



BIGSKYCARBON SEQUESTRATION PARTNERSHIP

The Plains CO_2 Reduction Partnership PCOR

West Coast Regional Carbon Sequestration Partnership westcarb.org

MRCSP Midwest Regional Carbon Sequestration Partnership

MGSC

SWP Southwest Partnership CO_2 Sequestration

Southeast Regional Carbon Sequestration Partnership

NETL

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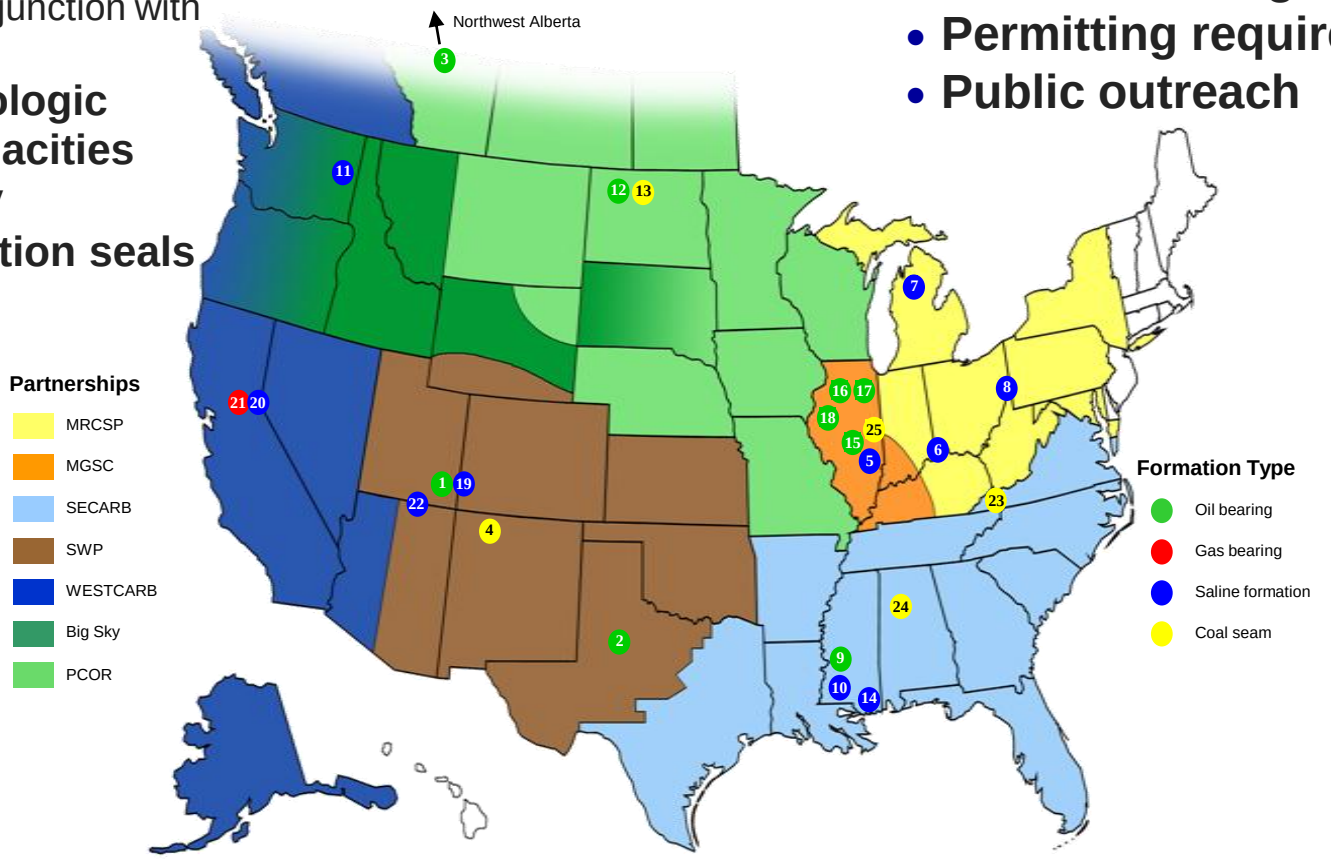
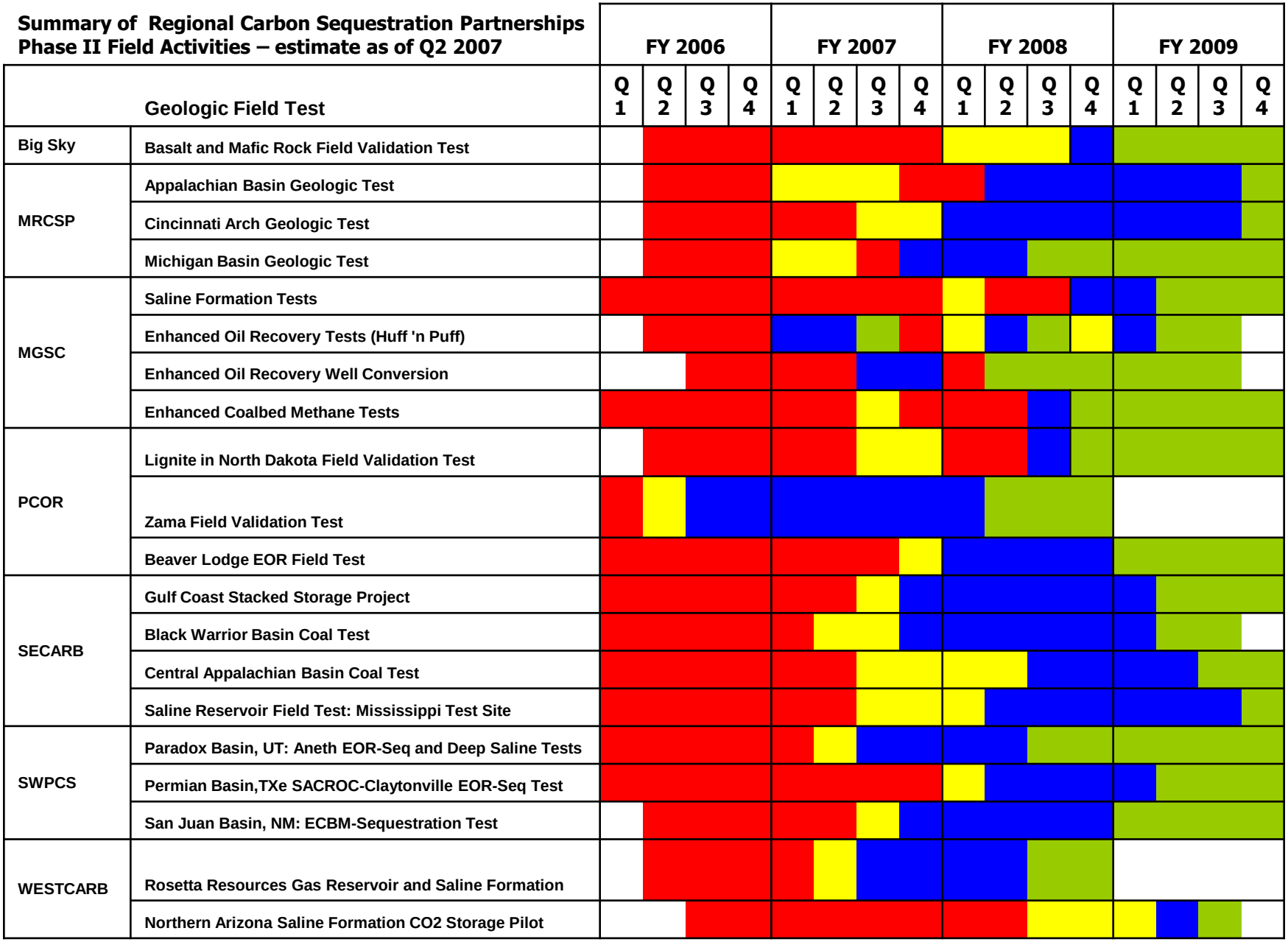
Phase II Field Validation
25 Geologic Tests

- **Injections 750-525,000 Tons CO_2**
  - Larger in conjunction with EOR
- **Validating geologic formation capacities and injectivity**
- **Testing formation seals**

- **MMV technologies**
- **Permitting requirements**
- **Public outreach**



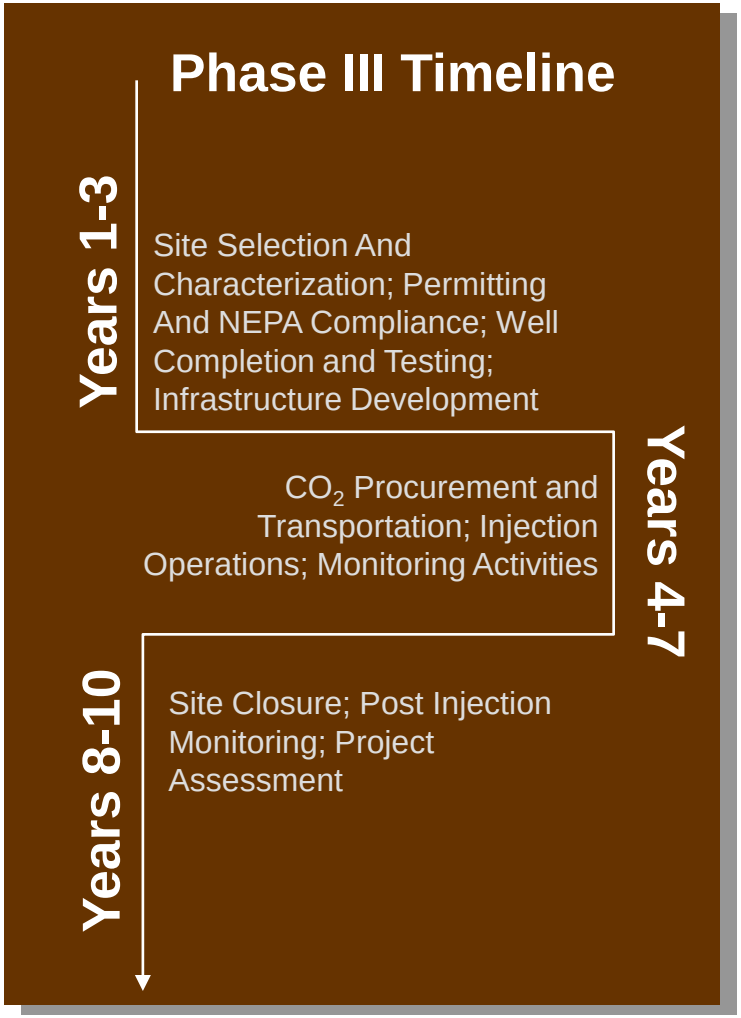
Summary of Regional Carbon Sequestration Partnerships Phase II Field Activities – estimate as of Q2 2007



Deployment Phase

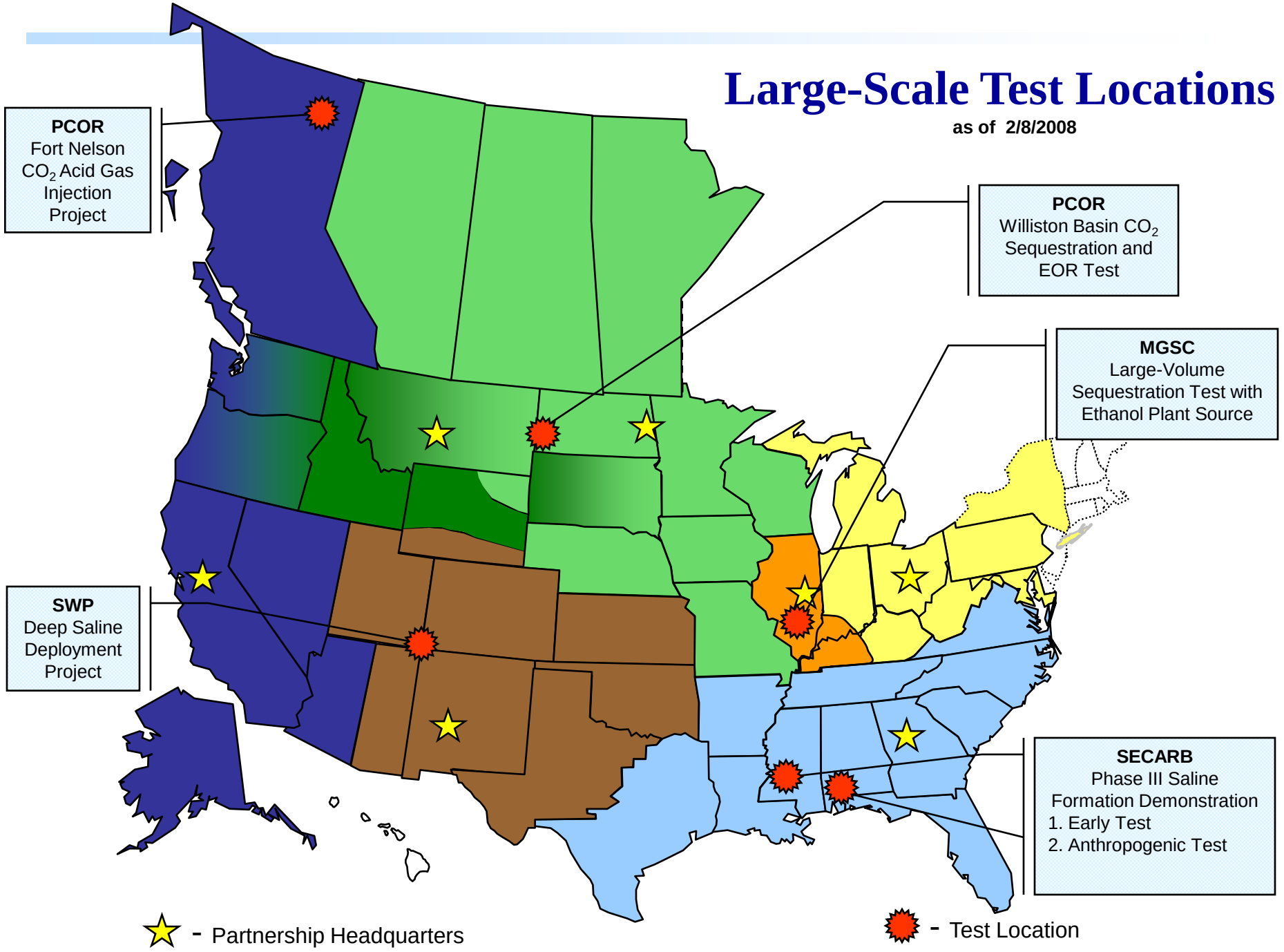
Scaling Up Towards Commercialization

- **FY 2008-2017 (10 years)**
- **Several large-volume sequestration tests in North America**
- **Injection rates up to 1,000,000 tons per year for several years**
- **Scale up is required to provide insight into several operational and technical issues in different formations**



Large-Scale Test Locations

as of 2/8/2008



Deployment Phase Outcomes

- **Site characterization requirements**
- **Storage capacity assessment**
- **Design criteria**
  - Injection wells
  - Regional monitoring, mitigation, and verification program
  - Site closure
- **Permitting requirements**
- **Validate reservoir and risk assessment models**
- **Accelerate public outreach**
- **Science Protocols**
- **Best practice manuals**

Carbon Sequestration Leadership Forum (CSLF)

- CSLF charter signed on 25 June 2003 in Washington, DC
- International climate change initiative
- Facilitate development of cost-effective technologies
- Promotes technical, political, and regulatory environments to develop such technology
- Technical and Policy Committees, including Capacity Building and Financing Task Forces
- 20 approved RD&D projects

Carbon Sequestration Leadership Forum (CSLF) Membership

- Australia
- Brazil
- Canada
- China
- Colombia
- Denmark
- European Commission
- France
- Germany
- Greece
- India

- Italy
- Japan
- Republic of Korea
- Mexico
- Netherlands
- Norway
- Russian Federation
- Saudi Arabia
- South Africa
- United Kingdom
- United States

Developing Member Countries

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http://fossil.energy.gov/

http://www.netl.doe.gov